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OBSERVATIONS ON THE EFFECTS OF ELECTRIC CURRENTS UPON THE LIVING TISSUES, AND UPON NUTRITION.

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*Traumatic Paralysis.**—Mademoiselle Barbe Seifert, aged nineteen years, had been operated upon by Prof. Thiersch for a tumor, which showed itself beneath the left ear. The facial nerve was divided in the extirpation, and there resulted a complete paralysis of all the muscles of the right side of the face. At he end of twenty days, the wound had completely healed, and the sensibility remained normal.

The induction current gave no indication of contraction for any of the muscles of the paralysed side, whether the interruptions were strong or feeble, rapid or slow. A current of ten elements of the apparatus of Stohrer produced contractions of all these muscles. The contractions were stronger in placing the negative pole upon the muscles and the positive at the nape of the neck, than when the inverse disposition was employed. The contractions of the paralyzed muscles were, however, less strong and more sluggish than those of the sound muscles.

At the end of three weeks, excitation of the branches of the facial nerve failed to produce contractions, whether under the influence of the induced current, or under the influence of the current of the pile. But direct electrization of the muscles produced well pronounced contractions with the current of the pile, but not with the induced current.

In other cases of facial paralysis, Meyer, of Berlin* has observed that when muscular contraction is still produced by induced currents, the continuous currents determine contractions more feeble than in cases where the induced currents are unable to produce any contraction. These cases, in general, are cured more promptly.

We have had occasion to observe two cases of facial paralysis, the one rheumatic and the other traumatic, where this difference of action between the induced current and the current of the pile was very remarkable.

Mr. G——, merchant, had left one of his bed-room windows open during the night (June, 1867). The next morning he awoke with the entire right half of the body completely paralyzed. The mouth was strongly drawn to the left side; any movement of the muscles of the right cheek was impossible; he could neither blow nor whistle; when he ate, he was obliged, at every moment, to push the food towards the right cheek with his fingers; he was unable to close his eyelids.

Sensibility was very well preserved. Electrized with a very feeble current of the pile (ten elements of Remak), all the muscles of the face on the paralyzed side contracted perfectly. The induction current on the other hand did not produce any contraction.

In proportion as the cure, which became complete, at the end of twenty sittings, progressed, it became necessary to employ a stronger current (twelve, fifteen, then twenty elements) to produce contractions of the muscles of the face. During all this time the induction currents, applied as strong as they could be supported, did not produce any contraction.

We had occasion to see this patient again more than a year after his recovery, and although during the first weeks of his facial

*Loc. cit., p. 81.

*Die Electricitat in ihrer anwendung auf praktische Medicin. (Lately translated into English by Prof. Hammond, New York.)

paralysis, a current of ten elements of Remak provoked contractions, we were only able to obtain very feeble contractions with twenty-five elements.

Mademoiselle H——, five years previously, had a tumor removed, which had been situated along the ramus of the lower jaw, below the right ear. Her features were perfectly regular before the operation; right after the operation she had a complete paralysis of the side on which the tumor had been located. We did not see the patient at this time, but she asserted that the mouth had been drawn to one side more than at the time we saw it, and that it had also been more difficult for her to eat and to speak. We saw her three years after the operation, that is to say after the traumatic paralysis of the right facial nerve, and we could detect all the phenomena which accompany facial paralysis. She had, for several months, followed a treatment by induction currents. Continuous currents were not more successful; except that during several hours after electrization the muscles of the paralyzed side remained less relaxed, and consequently the countenance seemed to resume its normal appearance. This effect was only temporary, and was most marked immediately after electrization.

Induction currents, as we had proved two years before, and still more recently, could not produce any appreciable contraction of the muscles of the paralyzed side. Continuous currents, on the contrary, always produced very marked contractions even with a feeble intensity. These same currents and with the same intensity, did not provoke any contraction upon the corresponding muscles of the sound side. More than four years after the commencement of the paralysis then, this difference of action of the electric currents was still observed; and in this relation, the case appears to us to have a great deal of importance.

These differences of action do not exist only in cases of paralysis of the facial nerve; they are equally observed in other rheumatic and traumatic paralyses, as is proven by the following observation taken from Liemssen:*

A little girl tumbling from a chair, broke her left fore-arm towards the inferior third. The accident occurred in March, 1868, but the patient did not enter the hospital until May 17th. The forearm was deformed and its inferior portion prominent; the patient supported the left arm with the right hand, and was able to perform voluntary movements only with great difficulty.

The patient was placed under chloroform, and the muscles were electrized both with the induced and with the continuous currents. The induced current produced contractions in all the muscles of the forearm, except the common extensor of the fingers. This same muscle remained unmoved in electrizing the radial nerve. The continuous current, on the contrary, produced contraction of this muscle, more strongly than with the corresponding muscle of the right side.

May 22d. The same set of phenomena were observed.

May 30th. The mobility of the muscles of the paralyzed muscles was improved.

The child seized hold of objects better, and held them more firmly for a longer time.

After having moistened the forearm for some time, so as to facilitate the conducting power of the epidermis, we observed that a current of ten elements produced contraction of the paralyzed common extensor muscle; but not of the corresponding muscle of the sound arm. With twelve elements, the contraction of the left (paralyzed) side was very strong, while it was entirely wanting upon the right; and it was only with fourteen elements that we obtained a very sluggish contraction upon the sound side.

The induced currents, whether strong or weak, slowly or rapidly interrupted, produced no contraction of the paralyzed side, while they produced tetanic-like contraction of the corresponding muscles of the sound side.

June 19th. The position of the hand, as well as the extension of the fingers, had become sensibly improved. The excitability under the influence of the currents of the pile was much diminished, that is to say that a current of sixteen elements did not produce any contraction, while a current of ten elements had produced contraction upon the 30th of May. Induced currents produced then sluggish contractions in the paralyzed muscle.

Phenomena of the same character were observed by Liemssen in a case of cubital paralysis.

The following are the principal deductions which this physician draws from his different observations:

I. There exist cases of peripheric paralysis where the muscles do not contract, neither

*Loc. cit., pp. 92 and 93.

under the influence of the will, nor under that of induced or continuous currents.

II. In some cases, the motility is in part preserved, but neither the affected muscles nor their motor nerves are excitable, whether by induced currents or currents of the pile. (Eulenburg (*), Liemssen.)

III. The motility may be completely extinguished, while the muscular excitability for both sort of currents is enfeebled and equal (Meyer).

IV. The muscles and the motor nerves have lost all excitability under the influence of the will and of induced currents, while the excitability is augmented with currents of the pile.

In this case the observations give for result, the following phenomena:

A. DURING ABSENCE OF THE MOTILITY.

1st. The contractility is augmented by the current of the pile; a very feeble current which will not give any indication of contraction of the corresponding sound muscles, produces energetic contractions in the paralyzed muscles. (Baierlacher, Schulz, Neumann, Eulenburg, Liemssen).

2d. The excitability for the current of the pile augments during the course of treatment, attains rapidly a maximum, to diminish finally (Liemssen).

3d. The excitability for the current of the pile is not always increased at the same time in all the branches of the paralysed nerve. In the muscles and in the less excitable branches of the nerves, it augments and diminishes more slowly than in the muscles and in the branches of the more excitable nerves (Liemssen).

4th. The contraction produced by the currents of the pile, is less rapid in the paralyzed muscles than in the healthy muscles.

5th. The contraction does not often arise except by direct irritation of the muscle; and not by irritation of the corresponding motor nerve. (Neumann, Liemssen.)

B. WITH THE RETURN OF MOTILITY.

6th. The excitability under the influence of the current of the pile is lost, little by little with the return of voluntary movement, during which the excitability by the induction current returns little by little. (Schulz, Liemssen.)

7th. The excitability by the current of the pile is lost little by little, with the return of motility; but the excitability by the induction current remains extinguished despite the complete re-establishment of the motility.

The excitability by the two sorts of currents does not become normal, but little by little, and in the same proportions after several months and several years. (Liemssen.)

8th. The excitability by induced currents, in re-appearing remains more feeble for the homologous muscles of the sound side.

9th. The excitability by the currents of the pile remains the same, and the excitability by induced currents, never returns. (Eulenberg, Liemssen.)

These conclusions apply not only to traumatic and rheumatic paralyses, for they are equally true in other cases. Liemssen has observed similar phenomena in the case of paralysis of the muscles of the veil of the palate following diphtheritic angina. In a patient thus affected, the speech became nasal; and each time that he attempted to swallow liquids they returned by the nasal fossæ. Movement of the muscles of the veil of the palate, both voluntary or reflex, were completely abolished.

The application of induced currents did not produce any contraction of these muscles. On the contrary, the currents of the pile of eight elements of Storher caused the glosso-staphylin and the pharyngo-staphylin muscles as well as the superior constrictor muscle of the pharynx to contract very energetically. After three sittings, the voluntary movements re-appeared to a feeble extent; and after nine sittings the cure was almost complete. Liquids could be swallowed, and the voice was no longer of nasal clang. After five more sittings the cure was complete, and remained so.

The difference between the effects of the two kinds of currents continued to be invariable; that is to say that the excitability to the currents of the pile did not diminish, and that it remained null to the induced current. The current produced by the magneto-electric apparatus, where the character (?) of the current remains the same, was also unable to produce contractions of the muscles of the neil of the palate, while it was able to contract the muscles of the face. A current of eight elements which was unable to establish contraction of the muscles of the face, caused the muscles of the veil of the palate to contract.

Mons. Bruckner* has observed in cases of degeneration of muscles, that while the induction current remains without effect upon these

(*) *Zur Therapie der rheumatischen Facial-Parlysen Deutches Archiv. fur klin. Medicin*, 1866.)

*Bruckner, *Ueber aas ausbleiben der Zeitung gelahmter Nerven und Musceln bei momentaner Untersuchung des contenten electrischen Strom.* 1865.

muscles, the current of eight elements contracts them at each closure of the circuit; and at the same time slow interruptions with the currents of the pile produce stronger contractions than rapid interruptions do. With these same currents very rapid interruptions, according to this author, did not produce any muscular contraction.

We have been able to confirm the existence of this same difference of action of the induction current, and current of the pile in a case of fatty degeneration of the muscles.

Mme. C——, aged thirty years, had begun about five years previous, to experience a difficulty in extending the ring finger of the right hand. The other fingers had become successively affected. During the past two years the left hand had become involved, and at the time of our examination she presented the following conditions: The extensor muscles had retained very nearly their normal volume, but they had lost in consistencey, and were only able to contract very slowly under the influence of the will. Both hands were half closed, and none of the fingers could be elevated. The flexor muscles were likewise a little enfeebled, but the patient was able to close the hand completely.

The induced current applied to the flexor muscles produced pretty powerful contractions, but less energetic for an equal intensity of current, than was produced upon the perfectly healthy muscles. These same currents, upon the extensor muscles, produced but a very feeble contraction, while the currents of the pile determined on these same muscles, and relatively to the induced currents, much stronger contractions. On placing one of the poles of the constant current upon the skin which covers the extensors, we could maintain the hand in extension.

This difference of action between the currents of the pile and the interrupted current, has likewise been observed by us in a case of lead paralysis, in the person of a workman who entered the Beaujon hospital under the service of Mons. Axenfeld. This patient had been affected with saturnine paralysis of the extensors, twelve years previously, and had been completely cured at that time. A similar affection had returned during the past two months. Both arms were involved, but the right arm especially. Induced currents, even tolerably feeble, produced contractions in all the muscles of the forearm, except in the extensor muscles of the fingers; but with a strong induced current, a sluggish contraction of these muscles could be obtained. When the skin was well moistened, and the induced current strong enough, the current traversed the arm and acted upon the flexors, the hand flexed upon the arm, and the fingers became flexed. We tried in this case, and without obtaining any difference of action, both electro-magnetic and magneto-electric apparatuses. The current of fifteen elements of Marie-Davy, on the contrary, did not effect any contraction upon all the healthy muscles, and contracted only the common extensor muscle of the fingers, the proper extensor of the index, and the extensors of the thumb; that is to say, those only upon which the induced current provoked no action. Prof. Axenfeld and Mons. Duchenne (of Boulogne) were witnesses of this fact.

We have endeavored to detect this difference of action between the currents of the pile and induced currents, in other cases of saturnine paralysis, but we have not observed it as distinctly as in the case just mentioned. Even in this case, the phenomena varied sometimes from one day to another. However, in the majority of other cases of saturnine paralysis there is a difference of action upon the muscles in favor of the continuous current, and this difference relates especially, according to our observation, to the duration of the malady, and the moment of the treatment during which the muscular contractility is examined. We are as yet unable to give more precise indications upon this point.

The lesson we learn from all these facts is, that there exists a very great difference of action between the currents of the pile and currents, of induction and that we should never confound their action even for contractility. As the currents of the pile do not produce as energetic and painful effects as induced currents, many physicians are unable to see anything more in the effects of currents of the pile than those effects produced by very feeble currents of induction; and they repeat in all sorts of manners that it is only a question of greater or less intensity.

We have dwelt so much upon these pathological facts, because they demonstrate in so palpable and summary a manner, a manner no one can be deceived, that there is by which ence between the action of these two a differkinds of electric currents, so great that one may act, so to say, contrarily to the other.

Again, the continuity possible with the currents of the pile, and the forced interruptions

of induced currents, does not constitute the sole difference between these two kinds of currents, as has long been believed; for, as all these facts go to prove, *the interrupted current of the pile differs essentially from the interrupting current of induction.* Although in this respect the two sorts of currents have a common character, that of interruption, they possess different propensities altogether,—in their mode of production, in their tension, and in their chemical action.

The importance of this difference to diagnosis is very great, for as can be readily understood, it is impossible to learn exactly the condition of a muscle if we are confined to the induced current in our exploration of its contractility.

In traumatic paralysis, in certain cases of rheumatismal paralysis, saturnine paralysis, in infantile * paralysis the muscles do not contract under the influence of induced currents, while they do contract, on the contrary, under the influence of continuous currents. It is equally necessary to take account of this difference of action in a therapeutic point of view, but we do not wish to insist upon those considerations at this place, because we have yet to examine this question in a physiological point of view.

Erb,† Hugo Liemssen, and August Weiss,‡ have endeavored to produce upon animals some of the varieties of peripheric paralysis which are observed in the human subject, sometimes by dividing the nerves, and sometimes by bruising them. There are some differences in the observations of these authors, but merely in reference to questions of detail; for they all accord as to the principal facts.

After the section or crushure of a peripheric nerve (the experiments have been made principally upon the anterior tibial nerve) we observe the loss of excitability, very rapidly. Often after twenty-four or forty-eight hours, the nerve is no longer excitable by electric currents, whether those of induction or those of the pile.

The duration of the loss of excitability varied between three weeks and seven months. A simple section of the nerve requires from four to eight weeks for the separation of the excitability. It requires on the contrary six to seven months, when a portion of nerve has been removed to the length of 3 or 4 millimeters.

When but a slight contusion of the nerve is made, the loss of excitability is of slight duration, but the excitability diminishes for both species of currents, especially for the induced current.

The return of the excitability in the wounded nerve always takes place in its central portion several days before appearing in the peripheral portion.

While induced and continuous currents produce the same force of excitation for the central portion, the excitation produced by the continuous current for the peripheral portion is greater than that produced by the induced current.

The return of the excitability of the nerve coincides with the return of the muscular excitability by the continuous current, and with the diminution of the muscular excitability by the continuous current.

MUSCLES.

CURRENTS OF INDUCTION.	CURRENTS OF THE PILE. (*Currents called Constant and Continuous.*)
The muscular excitability diminishes almost immediately after the section or compression of a peripheric nerve.	Almost immediately after the section of the nerve the muscular excitability is augmented.
Sometimes, however, the normal state exists several days after the lesion of the nerve. In this case the lesion has been made at considerable distance from the muscle.	In half the cases there is a slight diminution of excitability the second day, but which only lasts some little time.
The further the lesion is distant from the muscle, the longer the muscle remains without losing its excitability.	The excitability tends to augment during several weeks, so much so that feeble currents produce contraction of the muscles, which they do not produce on the sound muscles.
The loss of excitability varies between four and twenty-eight weeks.	For the sound muscles, the negative pole produces more energetic contractions; that is to say, that if in placing the positive pole directly upon the muscle, it is necessary to employ five elements to obtain a contraction, four will suffice when the negative pole is placed directly upon the muscle. The contrary takes place for the injured muscles, and it is necessary to employ from two to six elements more when the negative pole is placed upon the muscle than when the positive pole is placed there.
The return of the excitability occurs very slowly, and attains the normal state with difficulty.	The excitability of the muscles diminishes when it returns under the influence of induced currents.
Sometimes it does not reappear for years.	This excitability remains, however, during a long time, superior to that produced by induced currents.

ERB has sought to establish a relation between these modifications of electric excita-

* The Journal of Psychology of Hammond (1868-9) has published from various American authors, several cases of infantile paralysis cured by the continuous current.

†*Zur Pathologie and pathologischen Anatomie peripherischer Paralysen.* (*Deutsches arch. fur klin. med.* Bd. IV. et. Bd. v, 1868.)

‡*Die Veranderungen der Erregbarkeit bei traumatischen Lahmungen.* (*Deutsches arch. fur klin. med.* Bd. IV, 1868.

bility and the anatomical alterations. As for the nerves, it is recognized by most physiologists that the section or compression of the nervous tubes produces degeneration of the medullary sheath, and that the nervous element regenerates itself little by little. It is after this complete regeneration that the electric excitability reappears.

But on the other hand several observations demonstrate that the voluntary movements take place at an epoch when the electric excitability is completely wanting. Mons. Erb believes that this difference is owing to the fact that the axis cylinder is alone necessary for the *conduction* of excitation; while in order to be *excited directly* the nerve must be intact, that is to say compound, consisting of the axis cylinder and the myeline which surrounds it. We know that in alterations of nerves, it is the axis cylinder which persists the longest time, and in the regeneration it is that equally which appears the first.

This theory, which is very hypothetical, does not account for the difference of action of the two sorts of currents. Liemssen appears to us to have indicated one of the reasons which occasion this difference. He believes it due to the difference of rapidity of the two currents. The induced currents have an extreme velocity, their passage is brusque, momentaneous; they fulfil perfectly the conditions which, for sound nerves, calls forth the strongest excitation—that is to say the rapid change in the intensity of the current.

But if the nerve has undergone alteration, and we believe to have added this consideration to the fact signalized by Liemssen, its excitability is still less, and at the same time it is necessary that the excitant action exist longer.

The induced currents in this case act too rapidly, and are unable, in consequence, to produce the activity of the nerve. The currents of the pile, on the contrary, act during a longer or shorter time, at the will of the operator, and let him make the interruptions as frequently as he can, they will always be much less frequent than those produced by the induced current. Besides, as we have pointed out, if the interruption with the currents of the pile are too rapid, they determine less powerful contractions.

The same occurs with the muscles. If they are healthy there is no excitant comparable to induced currents; if, on the contrary, they are altered, their contraction is very feeble under the influence of these currents and very slow, for they are not as sensitive to the excitation.

This theory, however, is still insufficient, for if it does take account of the less energetic action of the induced current, it does not explain wherefore the altered muscles contract more energetically than the sound muscles under the influence of the continuous current. We shall attempt to complete this study by some personal researches.

We have been struck, for a long time, with the difference of action of the continuous current upon striated fibres and upon the non-striated fibres. While under the influence of these currents, the contraction of healthy striated fibres is feeble and momentary, it is on the contrary very marked, and often long persistent upon the smooth fibres.

In some experiments upon the contraction of the intestine, we have likewise observed several times, both with the manometer and with a registering apparatus, that when we could no longer obtain any contraction by the induced current, it could still be produced by the continuous current. In a former article we have given (*Recherches experimentales sur les mouvements de l'intestin*,) two tracings indicating contractions which were obtained with the continuous current when even the induced current failed to produce any effect.

In the striated muscles, fatigue and the diminution of contractility after death, gave still the same results.

Upon muscles which we have maintained contracted by induced currents during several minutes, we obtained still stronger contractions with the continuous current when the muscle was fatigued. Upon a muscle thus fatigued, we placed the two leopheres of an induced current directly upon it, which determined a permanent contraction. At the moment that the muscle was thus contracted by the passage of an induced current, we applied at the same time, the electrodes of a current of the pile, and under this influence, the muscle contracted still more. The continuous current gave then in this case a more powerful contraction than the induced current. This phenomena never occurred when the muscle was fresh.

When, by their death, the muscles gradually lose their excitability, the same difference occurs between the induced currents and the currents of the pile. Without detailing our experi-

ments upon animals, we may cite the observations which we have recently had opportunity to verify upon the human body. These researches were made by us in the laboratory of Mons. Robin and in his presence, upon the cadaver of a criminal who had been executed some hours previously. The execution took place at five o'clock in the morning, and at half-past seven all the muscles of the trunk still possessed their electric excitability; but no contraction was produced by acting directly upon the peripheral nerves or upon the spinal marrow. The excitability of the nerves then, as is already well known, is lost before that of the muscles.

Muscles exposed to the air lose their excitability very rapidly; but this is not the case with the deeper muscles. At half-past eleven, six hours and a half after death, the muscles of the calf still contracted under the influence of the electric currents, notwithstanding that cadaveric rigidity had already begun in the lower limbs. Mechanical excitation equally excited contraction of the muscular fibres, and it seemed to us that at this period the mechanical excitants acted more powerfully than when the muscles are alive.

The contractility appeared to us to persist longer in muscles with long fibres.

Upon the trapeze we have noted very marked contractions six hours and a half, and more, after death. These contractions were more energetic by the application of continuous currents than by those of induced currents, which is contrary to what takes place in fresh muscles.

The form of the contraction was entirely different from that which is obtained with fresh muscles. It was slow and progressive, and resembled more of the smooth muscular fibres. The contraction was a little more rapid with induced currents, but less powerful.

When electrization ceased, the muscles returned to themselves with equal slowness. This movement was more rapid when the muscles had been electrized with the induced current.

Instead of obtaining during the passage of the continuous current, a relaxation of the muscular fibres, as takes place with fresh muscles, the muscle electrized remained contracted during the whole time of the application of the currents. However, being pressed in our researches, we were not able to keep the continuous currents applied longer than from thirty to forty-five seconds, and we could not assure ourselves whether this state of contraction would continue several minutes. But, even in the conditions which we have indicated, this difference in the action of continuous currents upon these muscles, and upon fresh muscles, is very remarkable.

These different facts demonstrate to us that when from any cause (defect of nutrition, fatigue, death,) the striated muscles are subjected to a change in their normal state, they no longer respond to electric currents in the same manner as before. Thus, in case of rheumatic or traumatic paralysis, &c., (we have endeavored to prove that this fact is general) the muscular bundles undergo an alteration often appreciable to the microscope.

It is logical, then, to admit that in the pathological facts which we have cited, the continuous currents act more energetically upon injured muscles than upon sound muscles, because the muscular substance has undergone a special transformation which approaches the striated fibre to the smooth fibre, which may even be its embryonic condition. In fact we have observed phenomena of the same order in the muscles of embryos. Upon the young embryos of rats, living and near term, we have seen that in the first moments the induced currents and the currents of the pile produced contractions of the muscles of the limbs. But at the end of very little time the induced currents failed to produce contractions, while the currents of the pile produced comparatively strong contractions. In addition, the contraction produced by the continuous current is permanent and maintained during all the time in which the current is applied.

There is then a pathological condition of the muscular fibre where the induced currents no longer produce any contraction, or but very feeble contractions, while the currents of the pile (continuous currents) *determine very pronounced contractions, and often even more energetically than in the normal condition.*

NERVOUS SYSTEM.

I.

The effects of electric currents on the nervous system are very varied, and we cannot enter here into all the details. We only dwell upon one question, as interesting, in a practical point of view, as it is theoretically.

The importance which the German authorities attach to the facts discussed by Du Bois-Reymond is well known, and in all their works on Electro-therapeutics, they endeavor to ex-

plain the curative powers of electric currents in accordance with these facts. The tendency is a good one, certainly, but we believe it to be exaggerated. For one thing, the theory of Du Bois-Reymond is no longer tenable when he endeavors to identify the electric fluid with the nervous flux; and the hypothesis that, in paralysis, neuralgia, etc., they reinforce and modify the electric tonicity of a nerve appears to us not only an exaggeration, but a great error. In all affections of the nerves, as in those of every other species of anatomic element, the alteration consists in a modification of nutrition; and the electric currents act, the greater part of the time, according to us, only by their influence upon the intimate nutrition, upon the phenomena of endosmose and of capillarity, and upon the circulation. As to the electric currents of nerves and muscles, there are concomitant phenomena, and not exceptional.

The facts of anelectrotonos and of catelectrotonos, discovered by Pfluger, render these theories very seductive, and the entire German school adopt them in their dissertations upon the influence of currents, and upon the elective properties of nerves. A continuous current soothes because it produces anelectrotonos; the same excites because it produces the catelectrotonic condition. The one renders the molecules more mobile, the other maintains them in a stabile state; the one reinforces the currents proper, the other enfeebles them. The direction of the current, its intensity, its action upon the muscles of the arterioles, its electrolytic effects, everything disappears before this single law: the positive pole causes the excitability of the nerves to disappear because it determines the anelectrotonic state, and the negative pole augments the excitability because it produces the catelectrotonic state.

Thanks to Mattencci, all the incontestible facts upon which they uphold these theories, have received a simple and rigorous explanation; but up to the present time the German school has not yet taken any account of the experiments of this Italian savant. Mattencci argues from this principle easy of experimental demonstration, that even the most rapid passage of the current of the pile is accompanied by electrolytic phenomena: acids are deposited at the positive pole, and alkalies at the negative pole; and the experiments of physiologists have long made known that nerves lose their excitability in the presence of acids, and that their excitability is augmented, on the contrary, by the contact of feeble alkalies.

In an historical and theoretical point of view, it is very curious to compare these facts with those which have been discovered concerning vegetables, where it has been observed that the development of plants occurs more rapidly near the positive pole than at the negative pole. Here again, the effect is but indirect, for potassa and chalk form the salts dissolved in the water, are produced near the negative pole, while acids are disengaged at the positive pole. It is known that bases favor the transformation of starch into dextrine and sugar necessary for germination, while the presence of acids arrests this transformation.

In employing distilled water in such manner that the passage of the current produces only hydrogen at the negative electrode, and oxygen at the positive one, we favor, on the contrary, germination at the positive pole by the oxygen and ozone which are developed there.

II.

But however indirect, this predominant influence of the negative pole is no less remarkable; and as electrolytic phenomena have a very great action in physiological effects, it is necessary to consider them in a practical point of view.

Some experiments seem, besides, to demonstrate that the negative pole is alone efficacious in producing the decomposition of substances transmitted by a current, (Daniel, Vorcillet.) For example, in making an electric current traverse a series of U shaped tubes filled with chloride of gold, we notice, at the end of some time, that the gold decomposed proceeds from the liquid which is in connection with the negative electrodes. Chemical test proves that the liquid surrounding the positive electrodes does not part with its gold. The same occurs with other salts.

These facts, apparently in opposition to the laws of electolysis, which show that the quantities decomposed depend on the quantity of electricity which passes and not on the nature of the current, have explained by many physicists (d'Almeida, Poggendorf), just like the anomalies which are often encountered in the use of the voltameter (Jamin); but the fact itself is no less worthy of remark in a medical point of view. In the electrolysis of the tissues, the eschar furnished by the negative pole is,

in fact, always more considerable than that which is produced at the positive pole. More, we believe that it is in this chemical action, more considerable at the negative pole, that is to be attributed, at least in part, the greater excitation which the negative pole produces.

III.

These facts, purely physical, prove well that for the difference of action of the positive and negative poles, it is not necessary to resort to hypotheses which are all more or less obscure

The influence of the direction of the current, however, seems to us to be outside of the purely physical phenomena, and proper to the living nerves themselves. We have already said that the current in the centripetal direction, contracts the arterioles and diminishes the quantity of blood in the peripheric portions, while the centrifugal current, on the contrary, dilates the vessels. As the circulation has a great influence upon the excitability of the nerves, it is very probable that one portion of the action of currents on the nervous centres may be explained in this way.

Upon the other hand, the motor nerves transmit the nervous influence of the centres to the periphery, while the sensitive nerves transmit it from the periphery to the centres; and it is possible that a centrifugal current acts with more force upon the motor nerves, and a centripetal current with more force upon the sensitive nerves. This has in fact been demonstrated by the experience of various authors; and we have here collated the influence of the continuous current upon the peripheric nerves.

A. The descending current is that which acts most energetically upon the motor nerves.

B. The inverse or ascending current is the one which acts the most energetically upon the sensitive nerves.

C. The excitability of the nerves is diminished by a direct or descending current, and is augmented by an inverse or ascending current.

We have equally seen, in searching the influence of the direction of the currents upon the spinal marrow:—

D. That the descending current applied upon the spinal cord acts upon the motor nerves by direct, and not by reflex action.

E. That the ascending current augments the excitability of the cord, and that it acts upon the motor nerves by reflex action.

F. That the descendant current prevents reflex action, while an ascending current augments it.*

* *Memoires de la Societe de biologie.* Mai, 1868.

It is important to remark here that this has nothing to do with the local action of this or that pole. Of course, with a descending current for example, the positive pole is the one placed nearest the centres; and the partisans of electrotonos and catalectrotonos may object that this lesser excitability of the descending current is due to the presence of the positive pole near the centres. But were this the case, we ought to have, at the same time, an augmentation of excitability at the negative pole; but there is no such thing, however, under these conditions. The inverse current, likewise, should, according to this hypothesis, be always more excitant for the motor nerves than for the sensitive nerves, a condition equally contrary to the facts.

We admit, and we have given physical proof in its support, that when the two poles are placed upon any (one) surface of an organ, or when they are placed upon a nerve, separated from the centres, there is a great excitant action on the part of the negative pole. But when we act upon the nerves and upon the centres in such a manner as to have a sufficiently great extent of nervous substance between the two electrodes, the direction of the current has a very marked action, because according to its direction, and independently of the local action of the electrodes, it influences either the excitability of the motor nerves, or that of the sensitive nerves. The direction of induced currents even, seem to have a certain influence, for A. Becquerel has remarked that in the treatment of neuralgias by these currents it is better to employ the direct current.

This influence of the direction of the currents has great value in practice, and we attach great importance to it.

The German school appears to us to be in error in not taking into account the *direction* of the currents, but only the more excitant action of the negative pole; it discovers nothing in this action but a *molecular modification*, a *polarisation*, special and different at the two poles. Matteucci has proved in an incontestable manner, that these differences depend especially upon the *electrolytic phenomena*; and he insists at the same time upon the necessity to take into consideration the direction of the currents. However, these explanations for all these phenomena are, perhaps, too exclusively based upon the chemical action. For the nerve intact and attached to the centres, and above all protected by the surrounding tissues

ologists have long made known that nerves

the eschar furnished by the negative pole is,

and by the epidermis from the direct contact of the electrodes, we believe that the *direction alone* of the current has a great influence, according as it is identical with that of the flow of the nerve fluid or in the opposite direction.

CHAPTER V.

EFFECTS OF ELECTRIC CURRENTS UPON GENERAL NUTRITION.

I.

We have already seen the influence of electric currents upon the phenomena of endosmose and exosmose. It is incontestible that in traversing living bodies, electric currents may act in the same manner upon these phenomena, that is to say augment them. Nutrition is constituted by a continuous movement of molecular change which takes place by endosmose and exosmose; and consequently in augmenting these phenomena, we stimulate nutrition.

To appreciate the greater or less activity of nutrition, the best means is to study the variations which occur in the elimination of urea. Some physiologists maintain it is true, that urea is not directly formed in the tissues, and that it is formed only in the kidneys. Without entering into the details of this question, we will only remark that urea is a product of the oxidation of azotic substances, and even if it does not exist ready formed in the blood, the substances which give rise to it may exist in the blood before its entrance into the renal tissue. The kidneys may perhaps determine the formation of urea, but only in acting isomerically, so to speak; for we believe that it would be absurd to maintain that the oxidation of azotic substances does not occur but in the kidneys. Whatever may be the theory adopted, we can always judge of the activity of the nutrition of the tissues by the greater or less quantity of urea which is eliminated.

The experiments which we have undertaken upon this subject have been made upon ourselves and upon animals. We have presented the principal results to the Academy of Sciences (*).

We first analyzed the urine before electrization and after it, without paying any regard to the total quantity of the urine, or the time during which it was secreted. We thus determined that urine examined after the employment of interrupted currents, contained much less azote than before the electrization. We equally found less azote after the use of continuous centrifugal currents; but we found much more after using centripetal currents.

We append some figures which represent the azote obtained from 10 grammes of urine (*):

Ascending Current.		Descending Current.	
Before.	*After.*	*Before.*	*After.*
9 cc.	21 cc.	25 cc.	17 cc.
43	60	34	21

We remark that the quantity of urea is extremely variable in the rabbit, according as it may be fasting or undergoing digestion, sick or well. This will explain the notable differences of our analyses.

Without desiring to record all of our observations, we will mention the analagous analyses of the urine of one of ourselves, made before and after electrization of the vertebral column:

Ascending Current.		Descending Current.	
Before.	*After.*	*Before.*	*After.*
50 cc.	53 cc.	50 cc.	47 cc.
40	45	76	71

in 10 grammes of urine to each analysis.

In another series of observations, we examined the urine secreted in the twenty-four hours, before and after electrization. The rabbit was placed in a cage destined to collect the urine, and electrized during half an hour.

In these conditions we did not obtain very striking results, for at the end of twenty-four hours, a sort of equilibrium became established in the elimination of the urine, and we could not judge exactly as to what was the result of the currents.

Finally, in a third series, we analyzed the urine secreted in a given time before and after electrization. From more than 250 analyses of urine made under these diverse conditions we may conclude:

1st. That interrupted currents diminish the quantity of the urine as well as the quantity of azote.

2d. That continuous centrifugal currents habitually diminish the quantity of urea, and increase that of the urine.

3d. That continuous centripetal currents exaggerate the production of urea without notably increasing the secretion of urine, which is even sometimes diminished.

We are disposed to believe that interrupted currents enfeeble the phenomena of general nutrition, and that continuous currents in facilitating endosmose and dialysis, re-enforce the electro-capillary currents, increasing the

* *Comptes rendus des seances de l'Academie des sciences*, 19 juillet, 1869.

* In our analysis of urine we followed the process of M. Leconte, which consists in decomposing the urine by means of alkaline hypochlorites, and measuring the azote.

* *Memoires de la Societe de biologie.* Mai, 1868.

changes which occur in the tissues; above all, the centripetal current, in acting upon the central nervous system, determines a stronger reaction, a sort of artificial febrile state, which to us explains its effects.

II.

To study the influence of continuous currents upon general nutrition in another aspect, we day after day electrized some puppies born at the laboratory and raised by the mother.

We took three of them at random, and weighed them two days after birth (March 1, 1869).

No. 1 weighed	- - - - -	369 grammes.
" 2 "	- - - - - -	364 "
" 3 "	- - - - - -	382 "

We electrized No. 1 and No. 2 for a quarter of an hour every day by plunging one of the forepaws and one of the hinder ones in some tepid water containing the electrodes

No. 1. was electrized with the descending current, and No. 2. with the ascending current.

March 22d, a new weighing gave us

No. 1	(descendant)	weighed	1k, 456 gr.
" 2	(ascendant)	"	1k, 491 "

March 31st.

No. 1	(descendant)	weighed	1k, 880 gr.
" 2	(ascendant)	"	1k, 900 "
" 3	(not electrized at all)		1k, 860 "

We then discontinued electrizing No. 1, and in place of it electrized No. 3 every day.

April 15th, we had the following results:

No. 1	(no longer electrized) weighed	2k, 621 gr.
" 2	(electrized since Mar h 2,) "	2k, 817 "
" 3	(" " " 31,) "	2k, 763 "
" 4	(not electrized at all) "	2k, 345 "

Two other puppies which had never been electrized had died during this time. We presented these puppies to the *Societe de biologie*, and, by simple inspection, all the members present recognized this difference of development.

These figures show that the animals which had been electrized had developed more rapidly than the others, and it permitted the conclusion that continuous currents act upon the general nutrition in a very efficacious manner.

Nevertheless, we do not deny that these experiments have a relative value only, for there was nothing to allow us to suppose that all these puppies were begotten by the same father; and consequently it may be admitted, that by chance we selected those pups which were of stouter race.

The figures above, however, show us that one of these animals (No. 1), when no longer electrized, lost weight in proportion to the others: and on the other hand, all these puppies seemed to be of the same race.

Messrs. Bert having repeated this experiment upon young cobayes, announced at a meeting of the Society of Biology, in the month of July, that he had not remarked any difference between the animals which had been submitted to electrization, and those which had not. We add that Mr. Bert rationed his cobayes, which lessened the interest of his observations, for it is too evident that an animal cannot grow more rapidly than others, unless in a condition to receive more nourishment; a greater activity of nutrition implies the necessity for more copious alimentation.

III.

Nothing is more proper to show the difference of action of continuous or interrupted currents upon the living tissues, than the application of these currents upon certain elements of the organism devoid of nerves and vessels, but which are still endowed with movement. We speak of vibratile cilia and spermatozoa.

As regards spermatozoa, experiments analagous to our own have been made by Messrs. Prevost and Dumas. We were not aware of these previous observations when we commenced our researches, which conducted to identical results.

Vibratile ciliæ afford a still more evident demonstration than do spermatozoa, besides; which, their movement being always the same, we may hope to discover a difference of action to the continuous current, following the line of that current. At any rate, it was an interesting fact to verify.

We will explain, in a few words, how we arranged the experiment. Upon a glass dish, furnished with two metallic plates slightly separated, we placed the vibratile cilia or the spermatozoa, in such manner that they touched the two thin metal plates; these were placed in communication with electric apparatus furnished with a commutator.

The movements of the vibratile cilia of the pharyngeal cellules of the frog are notably accelerated by the passage of continuous electric currents, whatever may be the direction of the current; the observation is as distinct as possible in vibratile cilia in which the movements have become very slow; we see them take on a new vigor and move rapidly.

Induced currents, on the contrary, retard the movement of the cilia and then arrest it completely. The vitality of the anatomical elements, however, is not abolished after the cessation of the undulations, at least, when the current employed is very strong. In fact,

if one cease to electize them, or better, if we make use of continuous currents, the movement returns little by little. The experiment is most difficult to execute with the vibratile cilia of the tracheal cells of mammifers, but it occurs equally.

The action is very nearly the same with spermatozoa, but is not so distinct; the difference in the action of the continuous and interrupted currents is not so marked, although it is by no means doubtful.

It was in vain that we attempted to arrest the vibratile movement of the cilia with continuous currents, even in giving them a direction opposite to that of their movement, that is to say, placing the positive pole on the the side where the cilæ drooped, and negative on the side where they rise again; in spite of our attempts the undulations became more rapid.

It is impossible to refer the explanation of these facts to a modification of nutrition caused by the electrization of these elements separated from the remainder of the organism; it is equally impossible to invoke the chemical decomposition of liquids, for the augmentation in the rapidity of the movements is immediate under the influence of continued currents. There is a simple excitation of the anatomical element; this excitation is here represented by movements; it might be manifested by a production of heat, light, or of electricity, if the element was qualified to call forth these phenomena.

IV.

The chemical combinations of all sorts which take place in the living tissues give rise to electric currents. It is known that the currents have been shown in muscles and in the nerves. There exists equally a musculo-cutaneous current, and a current between the external and internal surface of the skin. (Cl. Bernard.)

It may even be said that there are no portions, nor elements of the organism, where electric currents do not take place. Mons. Becquerel has discovered that there is a production of electric currents in every capillary action,* and in consequence every part of the organism should give rise to the formation of currents, as well in the element themselves as in the interspaces which separate them.

M. Becquerel (*Comptes rendus de l'Academie des sciences*, 7 juin, 1869,) has found that the electro-motor force of arterial and nervous blood is equal to 0.57; that of a couple of nitric acid being 100. The electro-motor force which is manifested at the contact of venous blood coming from vessels contiguous to the femoral artery, and of a cellular tissue moistened by seriosity is 0.30, that of a couple of nitric acid being 100.

We believe that M. Becquerel is mistaken when he considers the morbid state of an organ as the result of the dilatation of the pores, and of the cessation of the electro-capillary forces; but what is certain, is that it supplies the only satisfactory explanation of the phenomena which go on in the capillaries. It is, in fact, difficult to comprehend that the laws of endosmose and of diffusion alone can account for the rapidity of the liquid and gaseous exchange which is made between the capillaries and the contiguous tissues. How is it, besides, that in one case (the greater circulation) oxygen, which has so much affinity for the globules of the blood, leaves the globules, and that the blood returns in the veins charged with carbonic acid? In another case, (the pulmonary circulation,) the blood arrives in the lungs, quickly gives up its carbonic acid and takes oxygen. Mons. Becquerel has only sought to explain the electro-capillary phenomena which pass in the capillaries of the tissues, but his theory is just as exact for the capillaries of the lungs. Solely, in the latter case, the phenomena are inverse, it is the carbonic acid which is expelled, and the oxygen which enters into the blood of the efferent vessels; but in addition, the electricity of the walls has also changed sides. The oxygen, in fact, instead of being on the internal surface, as in the capillaries of the tissues, is on the external surface of the capillaries of the lungs. The phenomena of exchange and of material transportation may then be, as is really the case, inverse in the two cases.

It is necessary to remark that all the phenomena of exchange of gases and liquids take place in the organism, with such rapidity that it is impossible to explain them by the single fact of endosmose, which, besides, is accompanied by electric phenomena, and which is augmented in notable proportion by the currents. Without the intervention of the electro-capillary phenomena, it is really impossible to explain the introduction of the carbonic acid into the capillaries. For the vessels of

* M. Becquerel recommends electro-capillary piles in every case where there is wanted slow, regular and continuous electric chemical action. These poles have, at the same time, a powerful tension, and if their construction was easy and less expensive, they would certainly be the most advantageous for employment in medicine.

the lungs it may be pretended, that oxygen has much affinity for the blood globules, and that the carbonic acid has none; but, for the capillaries of the tissues, how does it come that carbonic acid, which has so little affinity for the globules, deposits itself and even penetrates into the tissues, where the tension is more elevated than in the tissue whence it comes?

On the other hand, many experiments prove that the oxygen found in the blood, which returns to the lungs, exists in the state of ozone. And how can it be under this form if it does not prove of the influence of electric currents in the capillaries?

V.

In the chemical effects of electric currents, we observe a remarkable phenomena called *cementation*, and which consists in a molecular action, in virtue of which elements of different nature are introduced into the interior of the body, while others are expelled, and that without change in the form of the body. M. Becquerel has succeeded in obtaining many transformations of this nature, by the aid of voltaic currents, very feeble, but prolonged a long time. What is particularly remarkable in this order of phenomena, is that the effect is not only produced at the surface, but that it has an inter-molecular penetration, substituting one metal for another without alteration of the exterior form.

Is not this just what takes places in a great measure in organic bodies? The anatomical elements, muscular fibres, nervous cells, etc., suffer constantly molecular changes in all their parts, but the exterior form remains always the same. Certainly, and we have already said it often, electricity is not the first cause of these molecular transformations; but on the other side, it is more than a simple accessory phenomenon, for if the chemical combinations of the living tissues are not the effect of electric currents, it is incontestible that they give origin to electric currents, and that these in their turn influence these chemical combinations. How many facts taken from phenomena of daily occurrence show that, even for inorganic bodies, there is always an intimate relation between the production of a current and chemical action. Iron and brass undergo alteration more quickly when there are already some points of oxidation on their surface. It is the same with lead when in contact with an unoxidizable metal. With organic bodies these relations are still greater, and it even becomes difficult to define very exactly that which is cause and that which is effect. Animal heat, for example, is the result of oxidations which take place in the living tissues, but we cannot say exactly that it is the cause of the molecular changes which take place during life. It is not heat that puts into activity the oxidation which accompanies the hatching of the egg? It is not heat which, maintaining a certain mean, permits the organs the play of their functions, and favors in them their molecular modifications?

It is the same with the electric phenomena. Reason and experience have demonstrated that the chemical combinations which take place in all living tissues, engender electric currents, and not only in muscles and nerves, but in all the elements of the body, wherever, in a word, there is an exchange of material.

It is for this reason, that the currents act so energetically upon the nutrition, even of deeply situated parts, and Prof. Niemeyer, though little enthusiastic, regards them "*as a means more potent than any other whatever it may be, to modify the nutritive conditions of parts deeply situated.*" To deny that electric currents are formed in all the tissues, and that they contribute to nutrition, is to fall into an exaggeration greater perhaps than that of physicians who would have all vital phenomena dependent upon electric currents. The one class have reason enough to maintain that organic combinations do not give rise to any disengagement of heat; and the others, that the nervous influx, its propagation, its action upon the muscles, etc., is nothing else than a phenomenon of heat.

This assimilation, under certain conditions of heat and electric currents, shows us how we may, in a general manner, consider the effects of electricity upon living bodies. The one and the other of these agents are the result of the nutrition of the tissues, and both, acting from without, whether by the medium of ambiant heat, whether by a direct introduction for electricity, augment the vital energy and excite all the organs. On the other hand, their inopportune action, too long continued, or too great, exhausts and kills.

Most medicaments have no other end than to limit nutrition or to increase it; to destroy the too active agents of oxidation, is to introduce oxidizing substances into the organism. In the same manner, electric currents may be applied according to the case, to augment vital

actions or to moderate them. Their effect is more rapid and more energetic than that of heat, only because they have a much more powerful action upon all bodies. A very feeble current appears to make or break combinations upon which the most elevated temperature has no effect.

But electricity has no mysterious action upon organic bodies any more than upon inorganic bodies. If its first cause is unknown, it is the same of all other forces; and we are equally ignorant of the nature of heat and of light.

The only thing beside, that it is important to us to know, is its influence upon the elements of living bodies; its physical, chemical and physiological effects upon each organ and upon general nutrition; its differences of action according to its mode of production; and finally, the limits within which it may be employed.

Medical Societies.

MEDICAL SOCIETY OF WEST VIRGINIA.

We are gratified to learn that the effort to create a second Medical Society of West Virginia has been given up. It would appear that in the call for the formation of the now existing society, many physicians were overlooked who should have been notified and invited. This unintentional slight has been amended by the action of the society recently, and at a late meeting of physicians, at Point Pleasant, Dr. S. G. Shaw, presiding, it was

Resolved, 1st. That this convention deems it inexpedient to form an independent medical society in West Virginia.

2d. That in view of the recent action of the State Medical Society, it is the opinion and desire of this convention that all feeling of disaffection on the part of the profession in the State should cease, and that in future said society should receive the cordial support of every regular and respectable practitioner within our borders.

THE PHILADELPHIA HOSPITAL MEDICAL SOCIETY.

A Medical Society was organized on the evening of Nov. 2d, and adopted the name of the "Philadelphia Hospital Medical Society."

The Society is composed of local ex-residents and the resident staff of the hospital, and hold their meetings in the Library Room of the institution on the second and fourth Wednesday evenings of each month.

The following gentlemen were elected officers for the next six months:

Dr. J. Ewing Mears, *President.*
Dr. E. B. Mosei ey, 1*st Censor.*
Dr. H. W. Elmer, 2*d Censor.*
Dr. Geo. H. Fox, *Secretary.*

News and Miscellany.

Excessive Opium Eating.

Dr. A. T. Schertzer, of Baltimore, Md., relates the case of a lady, twenty-eight years of age, who had consumed in two years, *five thousand eight hundred and forty ounces* of laudanum, and spent *eleven hundred and sixty dollars* in purchasing it. Without pretending to hold her attending physician to an unjust responsibility, the question naturally occurs, as to whether or not this heroic consumption and lavish expenditure might not have been prevented by the employment of judicious means, in the first instance? Medical men should always bear in mind that this dangerous habit is easily acquired, and should guard as far as possible against it.

"While attached to the Medical Corps of the Navy," says Dr. S., "I have frequently met with natives of the East Indies who consumed opium with a voracity equal to that of the lady in question, but have never known a similar instance in this country."

QUERIES AND REPLIES.

Dr. J. W., Texas.—The last edition of the U. S. Dispensary can be bought for $8.00.

Dr. J. W. D., of Pa.—The Speculum, described in No. 11 current volume of Reporter, costs $15.00.

Dr. J. Q. R., of Pa.—We do *not* forward through our office the Journals with which we commute. The money is sent by us to the publishers of the respective journals, and the numbers are sent direct from the publishing office to subscribers. The Gynæcological Society's journal will be forwarded you with the Reporter for $7.50.

Dr. G. A. J., of N. J.—"Are we justified in tapping in congenital hydrocele, where it fails to be absorbed? Is there not danger of peritonitis?"

We think there is not much danger of the inflammatory action you fear, and that, *cæteris paribus*, you need not hesitate.

The Reporter, Compendium, and *Journal of Psychological Medicine* will cost $11.00.

The case of amenorrhœa you mention we cannot explain from the data given. Perhaps a uterine examination would reveal the true cause.

[Notices inserted in this column gratis, and are solicited from all parts of the country; Obituary Notices and Resolutions of Societies at ten cents per line, ten words to a line.]

MARRIED.

James—Eveland. On the evening of December 2nd, at the residence of the bride's parents by Rev. Theo. Stevens, Dr. John E. James to Miss Maria L., daughter of Daniel Eveland, all of Philadelphia.

DIED.

Zeigenfuss. In Buck Mount, Carbon co., Penn'a, on Tuesday, Dec. 7th, 1869, Dr. A. A. Zelgenfuss, aged 43 years.